UTILIZATION OF FREEWARE FOR NEW APPROACH OF STUDENT CENTERED MULTIMEDIA LEARNING MODULE FOR SCIENCE SUBJECTS

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ABSTRACT

In this article, the authors will discuss on the utilization of freeware from internet and easily accessible software for the development of new approach to student-centered learning module (SCLMM) for science subjects. Currently, there are many software which are able to contribute to the education field. However, those software or assistive technology software in the market are expensive and users have to pay for their licenses and are not easily accessible. Freeware is define as any software that can be found in the internet and require no license fee. Many of these freeware or applications can contribute to the education sector. In fact the SCLMM developed from freeware can enhance students' understanding on the scientific concept during their learning process. This encourages educators to develop their own SCLMM that allows active learning process for their students and also can be used for other method of teaching methodologies such as blended learning etc. This article further highlights some examples of freeware and possible practical implementation into SCLMM in a selected science topic. This new approach and with further effort on exploring the application of this freeware on other topics; we are hopeful that transforming science SCLMM in all levels of education into an entertaining and attractive learning activities will be achieved.

INTRODUCTION

E-learning has been one of the main trends in education nowadays. E-learning is defined as technology-based learning in which learning materials are delivered electronically to remote learners via a computer network [1]. In fact a student-centered learning module can be developed from freeware. This paper will start of by doing an overview of a few relevant educational theories. This is follow by how it applies into the development of this student-centered learning module together with the construction of the module, how to use it for learning process and finally showing the result of the effective study on a selected topic of physics.

BEHAVIORISM LEARNING THEORY

This module uses Behaviorism, Cognitivism, and Constructivism learning theories. Behaviorism learning theory stresses on the observable behavior [2]. While at the same time it neglects aspect such as mental processes. The intended behavior change occurs after the students were exposing to a particular program or event under strictly planned circumstances. The behavioral approach to learning has several important contributions to instruction including system for specifying learning objectives, mastery learning techniques, and direct instruction [3]. This shows that the role of teacher is instrumental in behaviorism. This is because teachers are the one that sets the class objectives, goals, and even learning outcomes. Through this, teachers are able to observe the

change in behavior of the students as intended. Hence behavioral objectives are instructional objectives stated in terms of observable behaviors [3]. Learning objective consists of three parts which includes the performance of learner (behavior), conditions for performance and criteria for acceptable performance [4]. Gagné' s nine key instructional events show both sides of a teaching process, from the teachers' perspective in planning and students' perspective in learning as shown in Table 1.

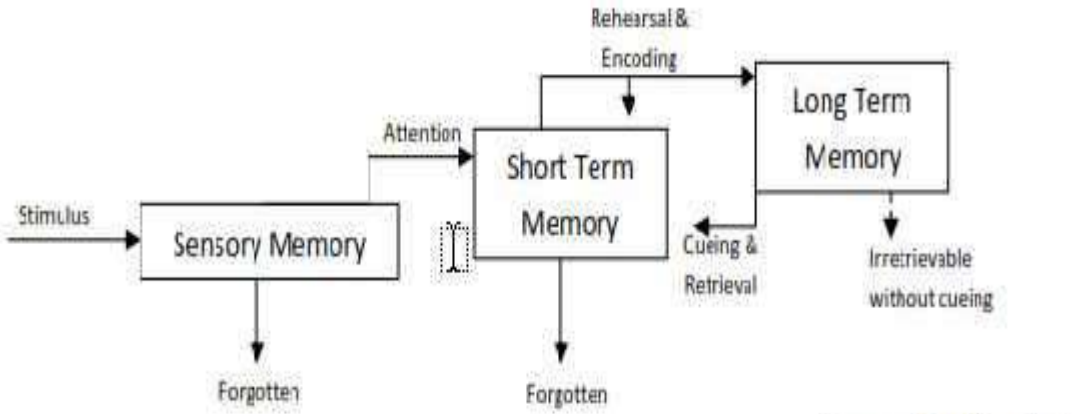
Table 1: Gagné' s Nine Key Instructional Events

Teacher/Design Action	Response of Learner
Gaining learner' sattention	Readiness
Stating session objectives	Knowing what to expect
Reminding what was done before	Stimulation of long term memory
Highlighting key features	Perceiving what is important
Structuring learning	Creating links and associations
Encouraging activity	Performing
Providing feedback	Learning awareness and satisfaction
Evaluating progress	Strengthening learning
Signalling future learning	Gaining learning overview

Source: Gagné and Medsker

Cognitivism Learning Theory

In Behavioral learning view, what is learned at the end is new behaviors [6]. This is where cognitive and behavioral views differ. In the cognitive view, knowledge is learned and changes in knowledge make changes in behavior possible [3]. Cognitivism focus on mental though processes such as the ways we think about situations, along with our knowledge, expectations, feelings, and interactions with others and the surrounding, influence how and what we learn[7], [8], [9], [10]. One of the information processing system model is shown in Figure 1.



Source: Carlile et.al.

Figure 1: Mental Processing

The processing information system model above shows three major elements, sensory memory, short term memory and long term memory. A person's receptors (seeing, hearing, smelling, tasting, touching) are influence by surrounding. Hence stimuli from the surrounding causes the sensations to be kept briefly in the sensory memory. However if any of the sensations were able to grasp the person's attention, it will be processed into the short-term memory element in some kind of patterns (such as music or picture), if not it will be forgotten. It is similar to the person's thought at that very moment. In order for it to be transferred to the long term memory, the information must be retain through different and attractive medium in presentation (such as mind-mapping [12]) or maintenance rehearsal and encoding. Given the name long-term memory, its' duration is practically unlimited and only can be retrieved if there is some sort of cue. Another interesting concept is 'de-centering' by the famous cognitivist, Piaget. This process was described as thinking from different perspective, different angles and from another person's view. De-centering concept encourages people to move beyond their own frame of thinking and reference [13], [14]. Some implications of cognitive for practice are shown in Table 2. However these suggestions do not serve as mere implications thus can also be seen as element to be considered in cognitive learning.

Table 2: Implications of Cognitivism for Practice

•	Promote active listening
•	Don't overload short term-memory by presenting too much material at once
•	Don't lecture for more than 20 minutes without a break
•	Chunk material into groups or categories to facilitate retention
•	Make the structure and patterning of the material explicit for learners
•	Present material in more than one form to facilitate transfer to long term memory
•	Give learners the opportunity to revisit topics to strengthen retention
•	Use key words and terms as memory cues
•	Outline the meta-cognitive strategies needed for your subject

Source: Carlile & Jordan (2005)

CONSTRUCTIVISM LEARNING THEORY

Then there is constructivism learning theory. Constructivists often describe the active role of the learner in constructing their *own meaning* based on what they know and their own experience [2], [3]. One of the significant aspect of constructivism with behavioural and cognitive learning is how the teaching and learning process being carried out by the teacher. In behaviourism, teacher needs to direct the students to achieve an intended behaviour. In cognitivism, teacher's teaching will shape the students' thinking such as the presentation medium used to stimuli students. While in constructivism learning, students take centre stage. This is where teacher needs to take into account what they know and learned before (learner's previous constructed meaning on something). Based on this they will then reconstruct new meaning through transforming and reorganizing. Hence teacher needs to align learning goals, teaching strategies, and how to assess students. One interesting question is how about children learning? This is due to children have little experience. Zone of Proximal Development (ZPD) developed by

Vygotsky suggest that student can learn by their own to a certain extent. Then the teacher will assist them through scaffolding. Scaffolding occurs when a teacher helps and guides a student and gradually dismantle this scaffolding so as to allow the student to become independent [15].

MULTIMEDIA LEARNING & COGNITIVE OVERLOAD

When developing the module, much importance were placed in learning from on screen text and images, or known as multimedia learning. Multimedia learning is defined as learning from words and pictures, while multimedia instruction is defined as presenting words and pictures that are intended to foster learning [16]. Nonetheless, multimedia learning just like any other learning, there are presence of obstacles in order for the learner is to achieve deep understanding. In this case it comes in the form of cognitive overload in multimedia learning. Consequently, multimedia instruction designer must tackle a central challenge known as cognitive overload in multimedia learning. Cognitive load refers to how cognitive resources are focused and used during learning and problem solving [17], [18]. If a learner' s intended cognitive processing outweigh the learner's cognitive capacity, it is known as cognitive overload [16].

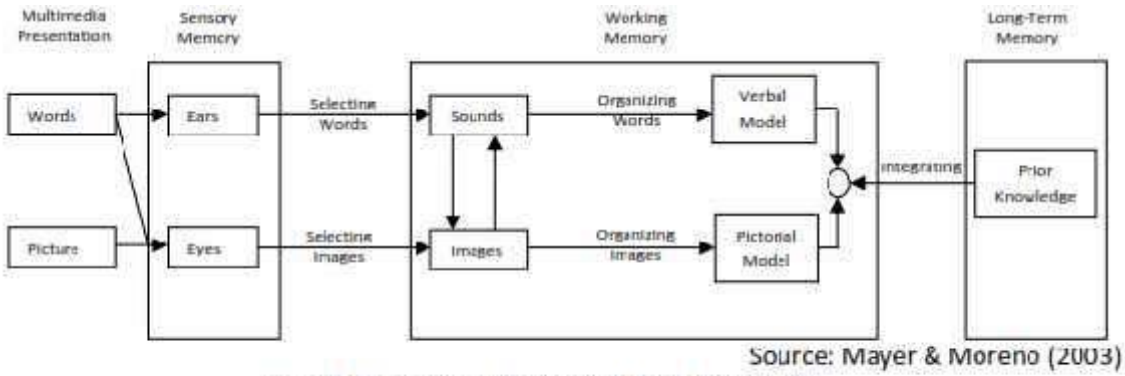


Figure 2: Cognitive Theory of Mental Processing

Figure 2 shows cognitive theory of mental processing. The top row display three major elements in cognitive theory which are sensory memory, working memory (short-term memory) and long-term memory. It consists of dual channel [16], [19], one is auditory channel (second row) and second is visual channel (third row). The arrows indicate mental action (cognition). Starting from the left, when a presentation is in the form of words (verbal) and picture, the receptors (ears & eyes) from the person will react. It all happens in the sensory memory. If there are any words or picture that capture the attention or intended by the person cognition process in the form of selecting words or images happen. The selected words or images will therefore be stored in working memory. There are two categories in working memory, shallow working memory (sounds & images) and deep working memory (verbal
& pictorial model). Deep working memory is where a person organize the selected sounds & images then construct it to a model. The circle in the right side of the working memory indicates merging process within the three, verbal model, pictorial model and prior knowledge. The capacity in long- term memory is virtually limitless. However the same cannot be said for working memory where its capacity is limited. This is where the cognitive overload occurs due to capacity limitation.

In the cognitive system there are three

kinds of cognitive demands that are essential processing, incidental processing, and representation holding (Refer Table 3). Table 4 shows five types of cognitive overload and some suggested solutions by Mayer and Moreno (2003).

Table 3: Three Kinds of Demands for Cognitive Processing in Multimedia Learning
Source: Mayer & Moreno (2003)

Type of Processing	Definiti
Essential processing	Aimed at making sense of the presented material including selecting, organizing, & integrating words and selecting, organizing, and integrating images.
Incidental processing	Aimed at nonessential aspects of the presented
Representational holding	Aimed at holding verbal & visual representations in working memory.

Table 4: Type Of Overload & Suggested Solution

	Type of Overload	**Type of Processing**	**Example of Problem**	**Suggested Solution**	**Example of Solution**
1	One channel is overloaded with essential processing demands	Essential Processing	This problem is also known as split-attention effect[18]. For example learner require to	Off-Loading	The on-screen text can be eliminated (off-load) and replace by a narrator.
2	Segmenting & pretraining when both channels are overloaded with essential processing demands in working memory	Essential Processing	For example if a narrated presentation is being displayed at a fast pace. Learner may not be able to grip the intended message.	Segmenting	Allow some time between successive segments.
3	Weeding & signaling when the system is overloaded by incidental processing demands due to extraneous material	Essential Processing Incidental Processing	For example if a narrated presentation is added with background music. Although the music might be interesting but it is considered as extraneous material.	Weeding	Eliminate the extraneous material (such as background music).
				Signaling	An alternative by stressing on intended picture and words through highlight or different tone of voice.

	Aligning & eliminating redundancy when system is overloaded by incidental	Essential Processing Incidental Processing	In a narrated presentation with subtitle. The images might be at the top and medium of the screen while the subtitle is located at the bottom. Learner might have to focus on presentation and the subtitle, which is of different position on screen, known as separated	Aligning words & pictures	Position the on-screen text next (or near) to the intended part of images.
				Eliminating redundancy	Eliminate the subtitle.
	Synchronizing & individualizing when the system is overloaded by the need to hold information in working memory	Essential Processing Representation Holding	The narration is presented first follow by presentation in visual. Learner needs to *hold* on to the verbal presentation in order to synchronize with visual.	Synchronizing	Synchronize both narration and visual to play at the same time.

DEVELOPMENT OF STUDENT-CENTERED MULTIMEDIA LEARNING MODULE USING FREEWARE

The developed module is in the form of multimedia instruction for a selected science subject and for example SCMILM of Light topic in physics, it consists of four sub-topics, Reflection, Refraction, Total Internal Refraction and Lenses for upper secondary curriculum in Malaysia or equivalent to O-level. For each sub-topic, there are three different type of video; there are virtual board video, virtual laboratory video, and virtual exercises video. These videos are developed based on the previously discussed theories of learning and in accordance with steps suggested (refer Table 4) to avoid cognitive overload. It will be discussed in sequence from virtual board, virtual laboratory and then virtual exercises. These entire video modules were developed using two freeware and an easily accessible software. The freeware include Screencast-O-Matic (SOM) and Windows Movie Maker (WMM). The other software is Microsoft PowerPoint. A block diagram illustrated on the development of SCLMM is shown in Figure 3.

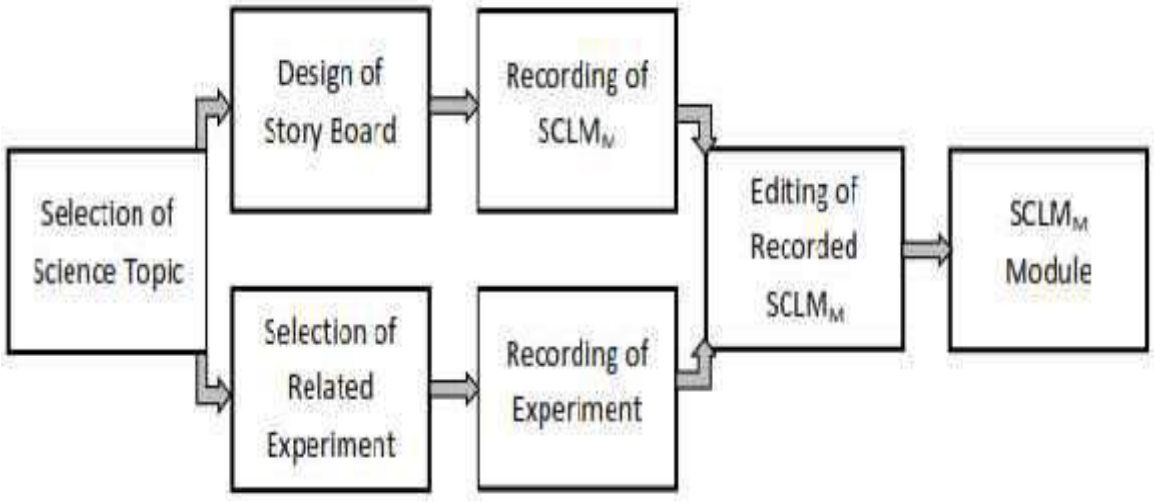
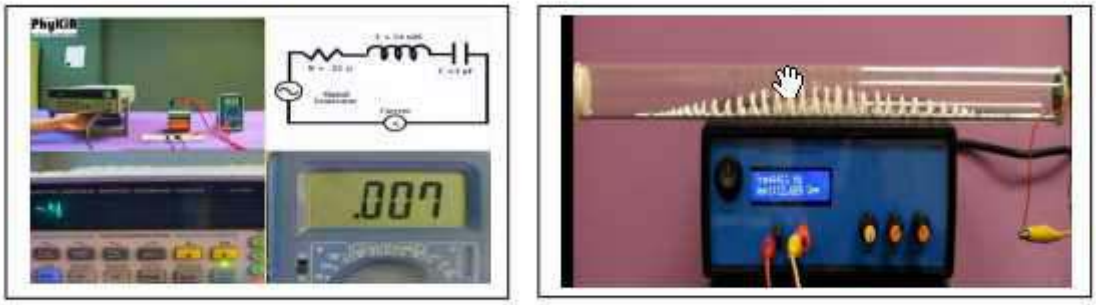


Figure 3: A block diagram of SCLMM development

The virtual board is a platform developed with an aim to explain the relevant theories and laws to learners. Now consider in traditional classroom environment, there is a whiteboard and marker. The teacher usually teach by using marker to write or draw images on the board while explaining to the students verbally. The concept used in virtual board is very similar. When the virtual video is play, computer screen is like the whiteboard. Images, animation and on-screen text will appear along with narration. Identical to blackboard, the background color of virtual will be black, the titles (and relevant subtitles) will be displayed at the top left in white. Virtual board concentrates on simple animation align with related key text and symbols. Signaling is used simultaneously with stressing tone on the intended (main) facts during the narrated animation. Different bright colors marker will be used to produce the animation and to create a striking animation (and images) to capture the learner's attention. The usage of simple animation is rather suitable given that for the topic light; a lot of explanations were related to ray diagrams. Hence this provides an alternative for the students to learn. The virtual board was developed using Microsoft PowerPoint, which is easily accessible and famous software. The main features used were shapes, text box, tables, animation and transition of slides while SOM is used as on-screen recording software. SOM is a freeware and it can be downloaded for free from internet. Besides, SOM is a friendly user freeware is shown in Figure 4. At the beginning of it is a slide containing one or two learning outcome(s). This will help students to know exactly what they expect to learn by watching the video and indirectly encourage them to relate with their previous knowledge or experience. At the end of the video will include a reflection phase to help students to relate the intended learning outcome(s) with what they learned throughout the content of the video. The reflection phase is either in a form of a (few) statements or table which last about ten to twenty seconds. Each virtual board videos are less than eight minutes. In general, virtual board is a set of instructional videos to explain a concept in a clear and concise manner in a short period of time.

Figure 4: Interface of Screencast-O-Matic

The virtual laboratory consists of two parts; the first part is to develop a hard or soft copy of the experimental manual while the later is to record the real experiment either using single camera to produce single frame video or four cameras to produce four frames recording video. For example, Figure 4 shows photographs of multi-frames and single frame virtual laboratory videos. Figure 4 (a) shows four cameras focusing at different equipment and object for RLC experiment, the top left is showing a whole experimental set-up, top right shows a circuit diagram, bottom left shows a camera position at a signal generator and the last frame showing a multimeter. If the frequency of a signal generator is changed to a certain value by the operator during experiment, the multimeter will measure the value of a current flowing in the circuit. Learners or students will observe and record all the corresponding data of the experiment. A hard copy manual of the experiment will be given to students. Figure 4 (b) shows a single frame virtual laboratory video, the learner will observe and record the frequency values when the particle resonate at a maximum vibration in a closed tube. As learners observe the play-back to the video clips, they interact with the instructions just like in any real-time experiment. These include collecting data, tabulating data, analyzing data and making the appropriate conclusion about the result. Learners also write report and present the experimental results. Many improvements were made in producing virtual laboratory video so that learners can relate the shown data with what they've learned before in the virtual board. Virtual laboratory can also be used as an alternative mechanism for achieving the same learning outcome(s) as in the corresponding physical laboratory [16]. One major enhancement in this virtual laboratory is the implementation of multi- frame display instead of the traditional one frame display. The multi-frame enables learner to view the experiment at different equipment and angles.



(a) (b)

Figure 4: Virtual laboratory videos (a) Multi-frame and (b) Single frame

Virtual exercises contain several questions to the related subtopics. Most of the exercises are mostly calculations. The main focus in virtual exercises is to guide learner to apply the learned knowledge such as formula and diagram when being presented with simple questions. All these instructional videos will be recorded using SOM, edited and produced using WMM. These freeware have been instrumental as they offer very similar functions to many similar software that required license fee.

MULTIMEDIA LEARNING VIDEO

These instructional videos can be used in a variety of ways. One of them is flipped classroom. The core idea in flipped classroom is to flip the common instructional approach, where students learn the intended subject at home, and during class period is to work through exercises, advance concepts and engage in collaborative learning [17]. However, the diversity of that definition means it is safe to say that there is no single model for flipped classroom. It is up to the creativity of individuals to explore this simple yet amazing strategy. So how to implement this set of virtual board, virtual laboratory and virtual exercises using flipped classroom? These instructional videos can be uploaded in the internet for example blog, YouTube, or website and which allows learners to access anytime, anywhere and will be able to repeat as many time as the like. A complete module for light topic is shown in Figure 5. Hence learners can study in advance before class at their own pace. Despite that, teacher must instruct the learners to do so. Then in class, teacher can allocate more time on students such as guiding them in exercises, and putting extra effort to enhance in their understanding of concept of certain science topic. In fact, teacher can conduct experiment and application of some science phenomenon in a more effective and systematic way because the students have already observed the respective videos in the classroom or at home, thus they know the procedures, what to predict, what data to collect, in short they already have (to some degree) an idea how to conduct the experiment. This teaching approach will able student to execute the real experiment in a very effective ways. They can even compare their own experimental data with the data or result from virtual laboratory. In addition, teacher can refer to the virtual laboratory video and obtain information that can be used for his/her teaching and learning process. With this, teacher can include additional related questions and exercises and graphs to strengthen the students' understanding. The role of teacher in the classroom will be more of a facilitator and this definitely contribute to the desired student-centered learning. A complete SCLMM graphic user interface of light topic is shown in Figure 5. The video can be viewed via computer, iPad, tablet and smartphone and the duration of each video is in between 4 to 8 minutes.

Figure 5: GUI of student centered learning module

EFFECTIVE INVESTIGATION BETWEEN SCLMM AND HARDCOPY MODULES

This study used pre-test and post-test experimental design. A total of 387 students were involved in the study. They were volunteers from three secondary schools in Malaysia. The secondary school were respectively labeled as K1, K2 and E1 where K1 and K2 were control groups while E1 was the experimental group. The difference between K1 and K2 were that respondents from both groups used modules available in their schools (in the form of notes and exercises) produced separately by their respective secondary school. The respondents from E1 group used SCLMM developed by our group. Initially, all three groups were tested through pre-test on the topic of Light. After that, they were given a period of two weeks to study and learn the topic of Light based on their respective approach (K1 & K2 used modules and E1 used SCLMM). Every day, respondents would spent roughly one hour to learn and teachers were voluntarily involved to ensure the flow and participation of respondents but without teaching the respondents. After two weeks, they were tested by using post-test on the topic of Light.

ANALYSIS AND DISCUSSION

In this study, one way ANOVA statistical test and Post Hoc Multiple Comparisons (Tukey HSD) test were used to evaluate the significant scores between groups. Results from one way ANOVA showed that $F(df=2, 384, p<.05)=9.248$ it is significant. Further analysis (refer Table 5) indicated that the mean score pre-test between group K1 and K2 is not significant (.859). However, the mean score pre-test between group K1 and E1 (.000), group K2 and E1 (.002) are significant. Relatively, group E1 has slightly the lowest mean score pre-test among the three groups.

Table 5: Post-Hoc Multiple Comparisons Test on Pretest

(I) Group	(J) Group	Mean Difference (I-J)	Sig.
K1	K2	.17299	.859
	E1	1.29346*	.000
K2	K1	-.17299	.859
	E1	1.12047*	.002
E1	K1	-1.29346*	.000
	K2	-1.12047*	.002

*The mean difference is significant at the .05 level.

One way ANOVA statistical test and Post Hoc Multiple Comparisons test (Tukey HSD) were also used to evaluate the significant scores between groups on posttest. Results from one way ANOVA showed that $F(df=2, 384, p<.05)=86.929$ it is significant. Hence, there is a significant difference in the mean score on post-test between all groups. Further analysis (refer Table 6) indicated that the mean score post-test between group K1 and K2 is not significant (.935). However, the mean score pre-test between group K1 and E1 (.000), group K2 and E1 (.000) are significant. Relatively, group E1 has the highest mean score post-test among the three groups. This shows that learning through SCLM is effective in improving the students understanding in the topic of Light.

Table 6: Post-Hoc Multiple Comparisons Test on Posttest

(I) Group	(J) Group	Mean Difference (I-J)	Sig.
K1	K2	-.15498	.935
	E1	-5.13774*	.000
K2	K1	.15498	.935
	E1	-4.98275*	.000
E1	K1	5.13774*	.000
	K2	4.98275*	.000

*The mean difference is significant at the .05 level.

CONCLUSION

Much can be contributed to the education field by utilizing freeware and easily accessible software. The Khan Academy has shown us amazing educational videos by utilizing this available software. Hence in this paper, a few innovations were introduced such as by using narrated simple animation (if possible) to provide clear and concise explanation of concepts, and the addition of virtual laboratory into SCLMM. In which the learners are expose to real science phenomenon and real experiment where real time data can be collected and analyzed. The suggested construction of the instructional videos is also in accordance with the educational theories described in the early part of this paper. Lastly, some recommendations were made regarding the implementation of these instructional videos especially in the current trend of educational that is flipped classroom and student-centered learning. The developed SCLMM is found to be effective as a learning alternative for student in physics subject.

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